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IN RE APPLICATION OF: Gunnar BAHLENBERG, et al.

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INTERNATIONAL FILING DATE: 27 OCTOBER 1998

FOR: IMPROVEMENTS IN, OR RELATING TO, NEAR-ECHO SUPPRESSION

**REQUEST FOR PRIORITY UNDER 35 U.S.C. 119**  
**AND THE INTERNATIONAL CONVENTION**

Assistant Commissioner for Patents  
Washington, D.C. 20231

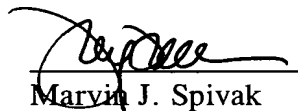
Sir:

In the matter of the above-identified application for patent, notice is hereby given that the applicant claims as priority:

<b><u>COUNTRY</u></b>	<b><u>APPLICATION NO</u></b>	<b><u>DAY/MONTH/YEAR</u></b>
SWEDEN	9704010-9	03 NOVEMBER 1997

Certified copies of the corresponding Convention application(s) were submitted to the International Bureau in PCT Application No. **PCT/SE98/01931**. Receipt of the certified copy(s) by the International Bureau in a timely manner under PCT Rule 17.1(a) has been acknowledged as evidenced by the attached PCT/IB/304.

Respectfully submitted,  
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PATENT- OCH REGISTRERINGSVERKET  
Patentavdelningen



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## Intyg Certificate

EJU

Härmed intygas att bifogade kopior överensstämmer med de handlingar som ursprungligen ingivits till Patent- och registreringsverket i nedannämnda ansökan.

*This is to certify that the annexed is a true copy of the documents as originally filed with the Patent- and Registration Office in connection with the following patent application.*

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För Patent- och registreringsverket  
For the Patent- and Registration Office

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## PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN  
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PATENT- OCH  
REGISTRERINGSVERKET  
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Improvements In, or Relating to, Near-Echo Suppression

The present invention relates to a hybrid circuit for 2-wire to 4-wire conversion in which near-echo is substantially reduced for short lines and to a duplex transmission system employing a plurality of said hybrids.

5 Hybrid balancing has been used for many years to make 4-wire to 2-wire conversions, and vice versa, for duplex systems using a single line. If the balance is less than ideal, a portion of the transmitted signal will leak through the hybrid into the received signal path. This is referred to as near-echo. If the near-echo is strong, compared to the received signal, more bits are required in an Analogue to Digital (A/D) convertor located in the receive path. The present invention relates to  
10 a technique for substantially suppressing near-echo before A/D conversion in 2-wire to 4-wire hybrid circuit.

A hybrid circuit, of the type to which the present invention relates, may be used with the invention described in our co-pending patent application Kgp 152/97,  
15 which relates to the application of the present invention to extending the reach of a VDSL.

According to a first aspect of the present invention, there is provided a hybrid circuit having a balanced 2-wire to 4-wire hybrid for interconnecting a two wire receive path and a two wire transmit path to a two wire transmission line, said  
20 two wire receive path connecting the balanced hybrid to an A/D convertor and said two wire transmit path connecting a D/A convertor to said balanced hybrid, characterised in that said two wire receive path contains a filter.

Said hybrid circuit may be adapted to operate with a transmission system employing FDD, and said filter may be dimensioned to reject transmit signals originating from said D/A convertor.  
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Said hybrid circuit may be adapted to operate with a transmission system employing OFDD, and said filter may be dimensioned to reject transmit sub-carriers

originating from said D/A convertor.

Said hybrid circuit may be adapted to operate with a duplex system having the following characteristics:

- all transmitters in ONUs and NTs in said duplex system are time synchronised;
- timing advance is calculated from line lengths;
- different sub-carriers are employed for up-stream and down-stream transmissions;
- a cyclic prefix is added to compensate for delay propagation in transmission lines; and
- frequencies above the FDD band are not employed for longer lines.

Said cyclic prefix may be dimensioned for lines of length X metres and OFDD is used for lines shorter than X metres.

Said balanced hybrid and said filter, together, may introduce a delay less than a delay for which said cyclic prefix is dimensioned.

According to a second aspect of the present invention, there is provided a duplex transmission system, characterised in that said duplex transmission system includes a plurality of hybrid circuits as described in any previous paragraph.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 illustrates, in schematic form, a hybrid circuit according to the present invention.

In order to facilitate an understanding of the present invention a glossary of terms used in the description of the present invention is provided below:

A/D:	Analogue to Digital
ADC:	Analogue to Digital Convertor
D/A:	Digital to Analogue
DAC:	Digital to Analogue Convertor
DMT:	Discrete Multi Tone
FDD:	Frequency Divided Duplex
NT:	Network Termination
OFDD:	Orthogonal Frequency Divided Duplex
ONU:	Optical Network Unit
VDSL:	Very high rate Digital Subscriber Line

Where an A/D convertor is located in the receive arm of a hybrid circuit, as illustrated in Figure 1, the number of bits required in the A/D convertor is determined from the input signal level. If the signal level is increased there will be a loss of resolution when the dynamic range is kept the same. If the near-echo is as strong as the received signal, the A/D convertor will require one extra bit to maintain the same resolution. For long lines, the received signal will be more attenuated than for shorter lines. The near-echo will not be affected by the line length. This means that longer lines will be more affected by the near-echo signal.

The present invention is particularly applicable to reducing near-echo signal

for the duplex scheme described in our co-pending patent application Kgp 152/97, and DMT symmetric transmission systems of the type described in our patent application PCT/SE 9600935. The basic concept presented in our co-pending application, Kgp 152/97, is the use of Frequency Divided Duplex (FDD) for transmission at lower frequencies and Orthogonal Frequency Divided Duplex (OFDD), also known as Zipper, for transmission at higher frequencies. For long lines only, FDD is used for the lower frequencies (FDD). For short lines, an arbitrary up-/down-stream loading is possible for the higher frequencies. The key elements in the duplex scheme are:

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- performance of time synchronisation between all transmitters in the ONU and the NTs;
- calculation of timing advance from the line length;
- use of different sub-carriers in up- and down-stream directions;
- addition of an extension of the cyclic prefix to compensate for delay propagation in the line - this extra cyclic prefix is dimensioned for X metres, where X is the length of the shorter line; and
- not using the frequencies above the FDD band for lines longer than X metres, which means that FDD is used for longer lines and that OFDD can be used for lines less than X m.

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To suppress the near-echo signal before A/D conversion, a filter is inserted, see Figure 1. This filter removes the transmitted signal in the FDD band described in our co-pending application Kgp 152/97, in which, where FDD is employed, different frequency bands are used for up- and down-stream bands. This enables filters to be used to separate up-stream bands from down-stream bands. For the ONU side, it will be the FDD downstream band that is filtered out and, for the NT side, it will be the FDD upstream band that is removed.

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For long lines, where only the lower frequencies are used, i.e. FDD is

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employed, there is almost no near-echo because of the filter. For shorter lines, where higher frequencies are used, near-echo will be reduced. Suppressing near-echo is more important for long lines where the received signal is more attenuated. To fulfil the orthogonality requirements, the delay of the hybrid plus the filter must be less than the delay for which the extra cyclic prefix is dimensioned.

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By using the present invention:

- the number of bits required in the A/D converter, when OFDD is used, is reduced; and
- for longer lines, near-echo is better suppressed.

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For the avoidance of doubt the term OFDD, as used in this specification, is intended to embrace similar duplex techniques, such as those employing DMT, wavelet multiplexing, or the like.

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## CLAIMS

1. A hybrid circuit having a balanced 2-wire to 4-wire hybrid for interconnecting a two wire receive path and a two wire transmit path to a two wire transmission line, said two wire receive path connecting the balanced hybrid to an A/D convertor and  
5 said two wire transmit path connecting a D/A convertor to said balanced hybrid, characterised in that said two wire receive path contains a filter.

2. A hybrid circuit, as claimed in claim 1, characterised in that said hybrid circuit is adapted to operate with a transmission system employing FDD, and in that said filter is dimensioned to reject transmit signals originating from said D/A convertor.

10 3. A hybrid circuit, as claimed in either claim 1, or claim 2, characterised in that said hybrid circuit is adapted to operate with a transmission system employing OFDD, and in that said filter is dimensioned to reject transmit sub-carriers originating from said D/A convertor.

15 4. A hybrid circuit as claimed in any previous claim, characterised in that said hybrid circuit is adapted to operate with a duplex system having the following characteristics:

- all transmitters in ONUs and NTs in said duplex system are time synchronised;
  - timing advance is calculated from line lengths;
- 
- 20 - different sub-carriers are employed for up-stream and down-stream transmissions;
  - a cyclic prefix is added to compensate for delay propagation in transmission lines; and
  - frequencies above the FDD band are not employed for longer lines.

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5. A hybrid circuit as claimed in claim 4, characterised in that said cyclic prefix is dimensioned for lines of length X metres and OFDD is used for lines shorter than X metres.

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6. A hybrid circuit, as claimed in either claim 4, or 5, characterised in that said balanced hybrid and said filter, together, introduce a delay less than a delay for which said cyclic prefix is dimensioned.

7. A duplex transmission system, characterised in that said duplex transmission system includes a plurality of hybrid circuits as claimed in any of claims 1 to 6.

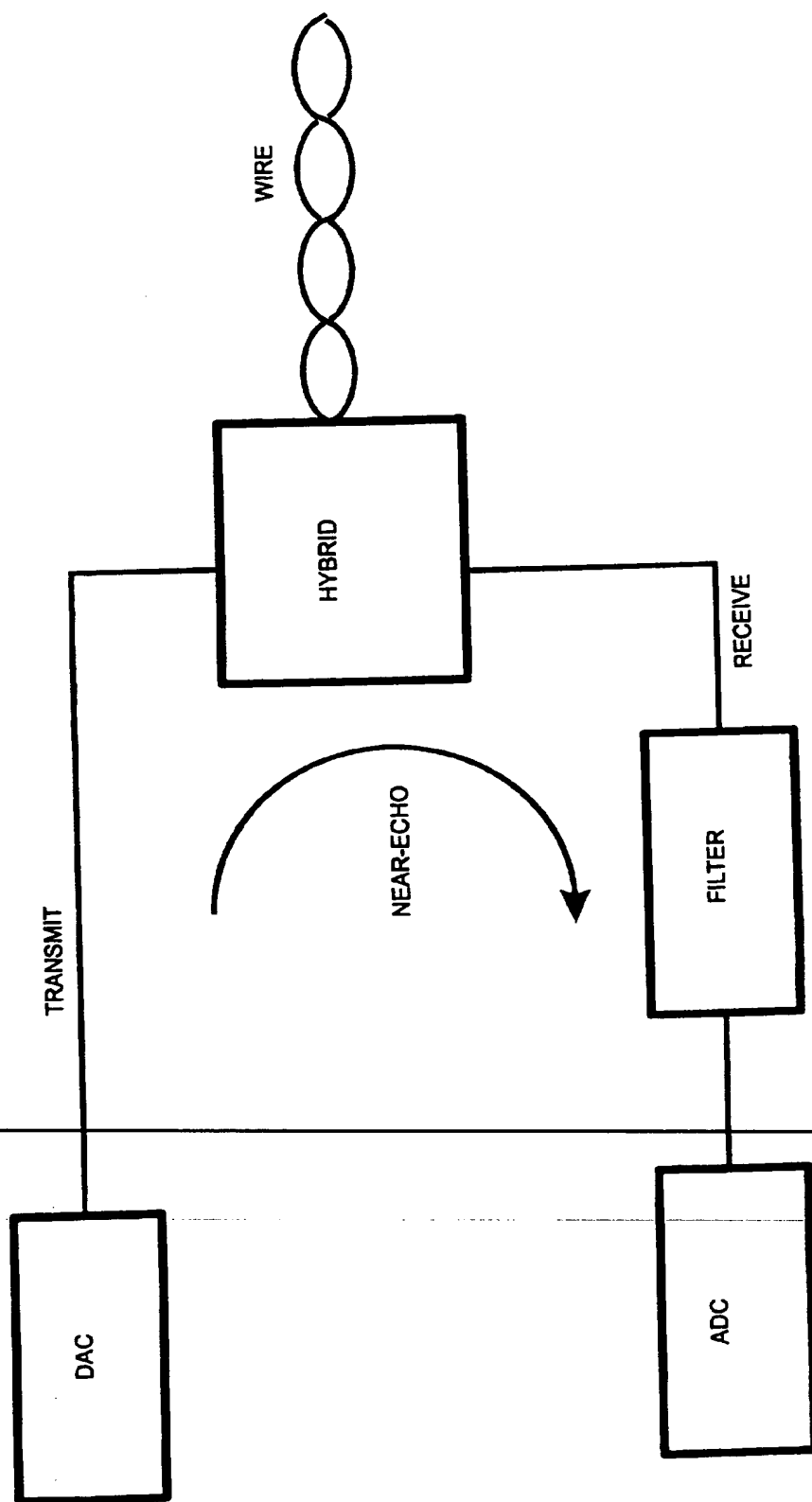
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ABSTRACTImprovements In, or Relating to, Near-Echo Suppression

The present invention, is a hybrid circuit which can be used to substantially reduce near echo signals. The circuit includes a balanced 2-wire to 4-wire hybrid for interconnecting a two wire receive path and a two wire transmit path to a two wire transmission line. The two wire receive path, connects the balanced hybrid to an A/D convertor and the two wire transmit path connects a D/A convertor to the balanced hybrid. The two wire receive path contains a filter, dimensioned to remove signals transmitted from the D/A convertor. The invention is particularly adapted for use with FDD and OFDD.

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**Figure 6**



# FIGUR 1